

CLAIMS

What is claimed is:

- 1 1. An optical attenuator device selectively operable in a  
2 non-actuated state and an actuated state, comprising:  
3 a waveguide for guiding optical energy, the waveguide  
4 having an input section coupled to an intermediate section,  
5 said intermediate section having reduced confinement of the  
6 optical energy relative to said input section;  
7 a thermal source, disposed above said intermediate  
8 section, for generating a temperature gradient within a  
9 portion of said intermediate section along a vertical axis  
10 thereof when said device is in said actuated state, said  
11 temperature gradient being sufficient to alter a refractive  
12 index profile within said intermediate section such that a  
13 portion of said optical energy is deflected downwardly and  
14 extracted from said intermediate section.
- 1 2. The device of claim 1, wherein said intermediate  
2 section of said waveguide comprises a core and a cladding  
3 bounding said core, said core and cladding having matched  
4 thermo-optic coefficients.
- 1 3. The device of claim 2, wherein said core of said  
2 intermediate section has at least one transverse dimension  
3 that is significantly larger than a corresponding  
4 transverse dimension of a core of said input section.
- 1 4. The device of claim 3, wherein said intermediate  
2 section is coupled to said input section by an adiabatic  
3 taper.

- 1 5. The device of claim 1, wherein said waveguide further  
2 comprises an output section optically coupled to said  
3 intermediate section, said output section having increased  
4 confinement of the optical energy relative to said  
5 intermediate section.
- 1 6. The device of claim 2, wherein said core is segmented.
- 1 7. The device of claim 2, wherein said core has a  
2 refractive index that is less than a refractive index of a  
3 core of said input section and greater than or equal to a  
4 refractive index of said cladding.
- 1 8. The device of claim 7, wherein said refractive index of  
2 said core of said intermediate section is equal to said  
3 refractive index of said cladding.
- 1 9. The device of claim 8, wherein said core of said  
2 intermediate section and said cladding are formed from the  
3 same material.
- 1 10. The device of claim 1, wherein said portion of said  
2 optical energy extracted from said intermediate section is  
3 adjusted by varying an electrical control signal applied to  
4 said thermal source.
- 1 11. The device of claim 2, wherein said core and said  
2 cladding are formed from polymeric materials.
- 1 12. A method for controllably removing optical energy from  
2 a waveguide, comprising the steps of:  
3 (a) directing said optical energy from an input  
4 section of said waveguide to an intermediate section of  
5 said waveguide, said intermediate section having reduced

6 confinement of said optical energy relative to said input  
7 section; and

8 (b) generating a vertical temperature gradient within  
9 said intermediate section sufficient to alter a refractive  
10 index profile within said intermediate section such that a  
11 portion of said optical energy is deflected downwardly and  
12 extracted from said intermediate section.

1 13. An optical attenuator device selectively operable in  
2 an actuated state and a non-actuated state, comprising:

3 a core;

4 a lower cladding layer downwardly bounding said core;

5 a first upper cladding sublayer upwardly and laterally  
6 bounding said core, wherein said core, said lower cladding  
7 layer and said first upper cladding sublayer have matched  
8 thermo-optic coefficients;

9 a second upper cladding sublayer upwardly adjacent to  
10 said first upper cladding sublayer and having a refractive  
11 index substantially lower than the refractive index of said  
12 first upper cladding sublayer; and

13 a resistive heater positioned above said core, said  
14 resistive heater being configured to generate a thermal  
15 gradient within said core, when said attenuator device is  
16 in the actuated state, such that the refractive index of a  
17 portion of said core is decreased below the refractive  
18 index of a portion of said lower cladding layer located  
19 downwardly adjacent to said core, causing a portion of the  
20 optical energy traveling along said core to be deflected  
21 downwardly and extracted from said core.

1 14. The device of claim 13, further comprising a substrate  
2 affixed to said lower cladding layer.

1 15. The device of claim 14, further comprising an adhesion  
2 layer interposed between said substrate and said lower  
3 cladding layer.

1 16. The device of claim 15 wherein said adhesion layer has  
2 a refractive index which is less than the refractive index  
3 of said substrate and greater than or equal to the  
4 refractive index of said lower cladding layer.

1 17. The device of claim 13, wherein said core, said lower  
2 cladding layer, said first upper cladding sublayer, and  
3 said second upper cladding sublayer all comprise polymeric  
4 materials.

1 18. The device of claim 13, wherein said portion of said  
2 optical energy extracted from core is adjusted by varying  
3 an electrical control signal applied to said resistive  
4 heater.

1 19. The device of claim 13, wherein said resistive heater  
2 is capable of generating an average vertical thermal  
3 gradient within said core of at least  $0.53^{\circ}\text{C}/\mu\text{m}$ .

1 20. The device of claim 13, wherein said resistive heater  
2 is capable of generating an average vertical thermal  
3 gradient within said core of at least  $0.67^{\circ}\text{C}/\mu\text{m}$ .

1 21. The device of claim 13, wherein said resistive heater  
2 is positioned no more than  $5\ \mu\text{m}$  above an upper boundary of  
3 said core.

1 22. The device of claim 13, wherein the portion of optical  
2 energy extracted from said core may be varied in a range  
3 between around 0% to around 99.9%.

1 23. An optical attenuator selectively operable in an  
2 actuated and a non-actuated state, comprising:

3 a core bound by a cladding, said core and said  
4 cladding having matched thermo-optic coefficients, said  
5 cladding having an upper surface;

6 a thermal source positioned above said core, said  
7 thermal source being configured, when said attenuator is in  
8 the actuated state, to generate a thermal gradient within  
9 said core such that the refractive index of a portion of  
10 said core is decreased below the refractive index of a  
11 portion of said cladding located downwardly adjacent to  
12 said core, causing a portion of optical energy traveling  
13 along said core to be deflected downwardly and extracted  
14 from said core; and

15 a cover plate affixed to said upper surface of said  
16 cladding and being held in vertically spaced apart relation  
17 with respect to said cladding.

1 24. The optical attenuator of claim 23, wherein said cover  
2 plate is affixed to said cladding by an adhesive applied to  
3 areas of said cladding away from said thermal source such  
4 that said thermal source is not contacted by either said  
5 adhesive or said cover plate.